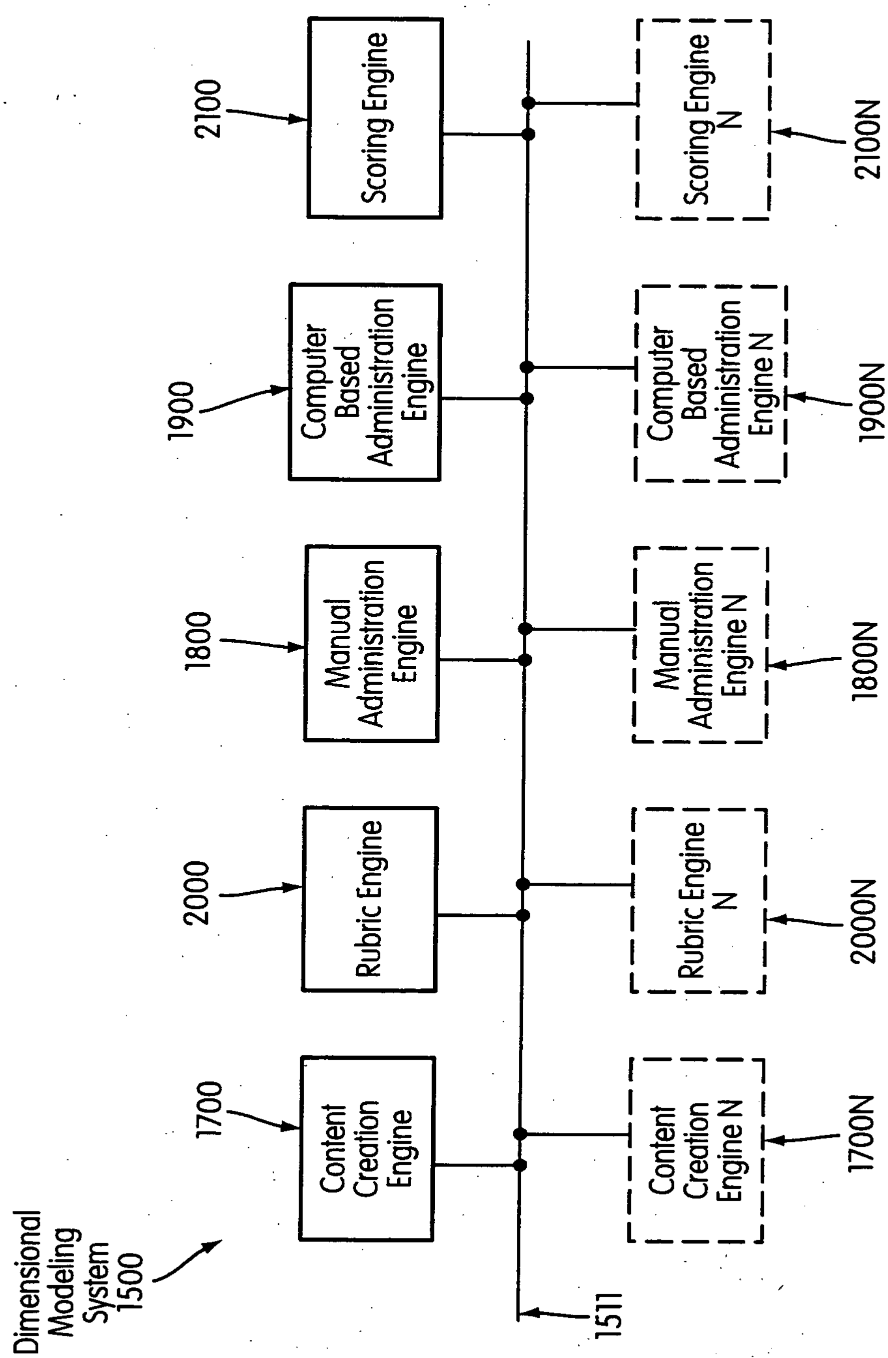

Dimensional Modeling System 1500
1511
1700
Content Creation Engine
2000
Rubric Engine
1800
Manual Administration Engine
1900
Computer Based Administration Engine
2100
Scoring Engine
Content Creation Engine N
1700N
Rubric Engine N
2000N
Manual Administration Engine N
1800N
Computer Based Administration Engine N
1900N
Scoring Engine N
2100N

FIG. 1

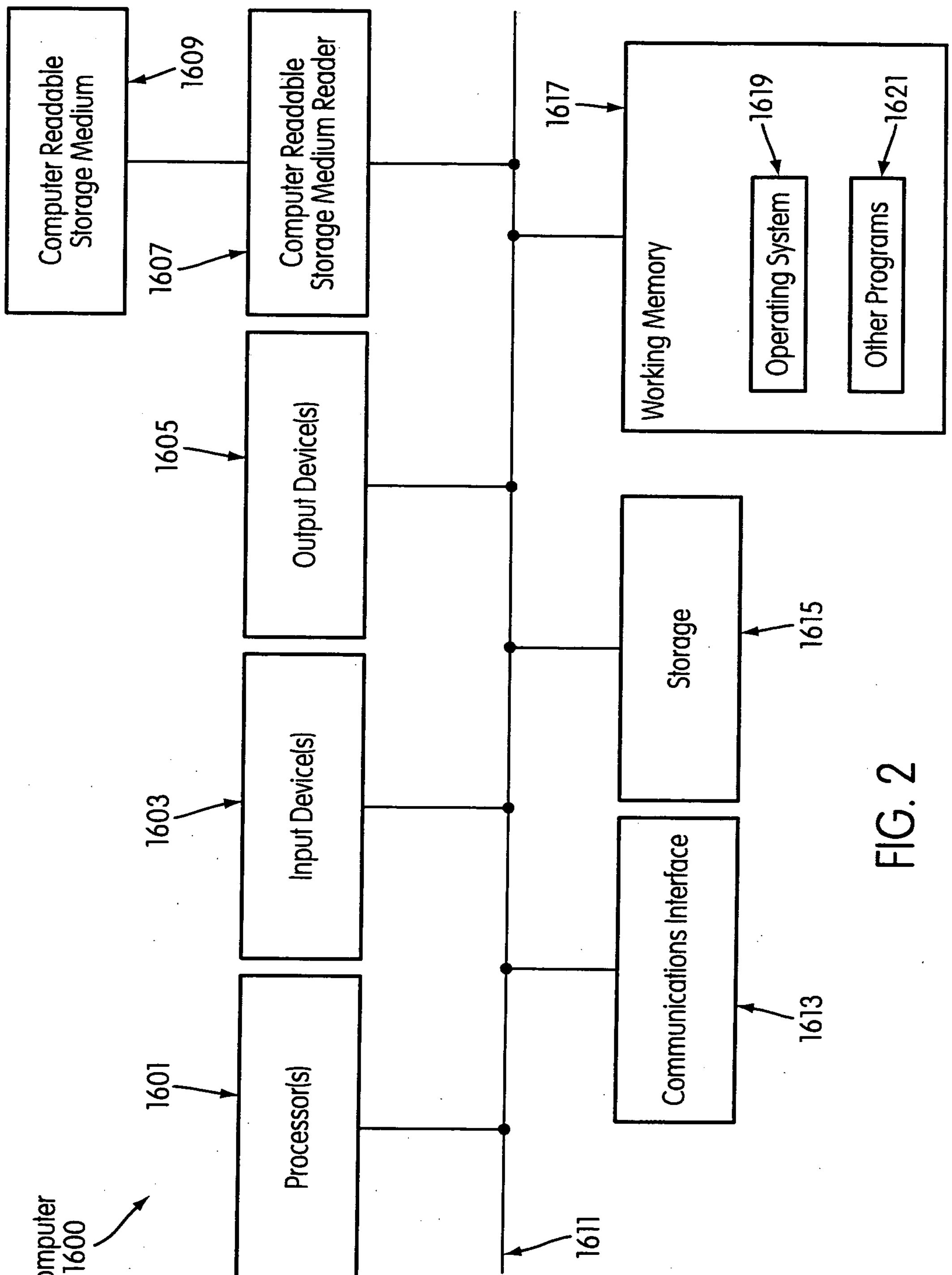

Computer 1600
Processor(s)
1601
Input Device(s)
1603
Output Device(s)
1605
Computer Readable Storage Medium Reader
1607
Computer Readable Storage Medium
1609
1611
Communications Interface
1613
Storage
1615
Working Memory
1617
Operating System
1619
Other Programs
1621

FIG. 2

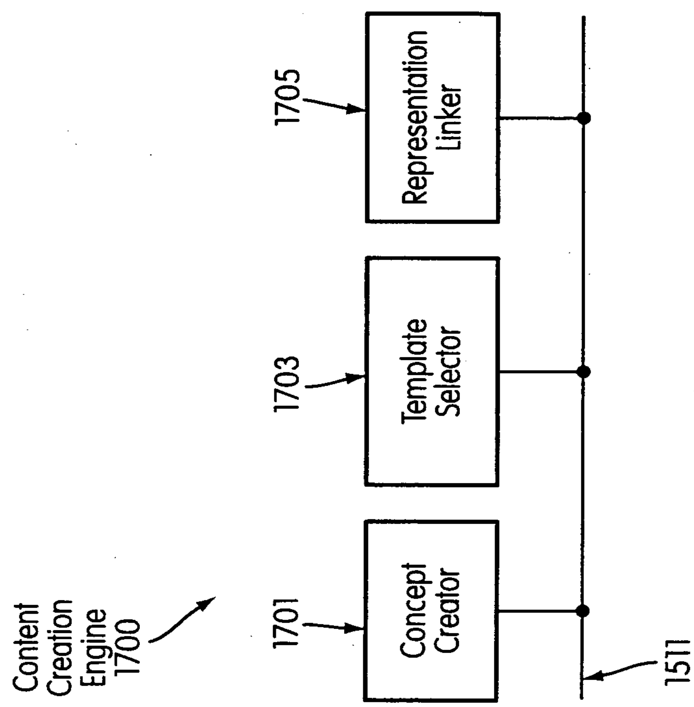

Content
Creation
Engine
1700
1701
Concept
Creator
1703
Template
Selector
1705
Representation
Linker
1511

FIG. 3

Topic	
Phases of the Moon	
ID	
007755	
Name	
Phase of the Moon Calendar Model	
Task Question	
What are the relative positions of the Earth, the Sun and the Moon for the following phases of the moon: full, half waning, new, and half waxing?	
Task Process	
Choose a date on the calendar which shows one of the phases of the moon and then show relative positions of the Earth, Sun and Moon when the moon is in that phase	
Concept	**Variable Attributes**
Sun	(x,y,t)
Earth	(x,y,t)
Moon	(x,y,t)

FIG. 4

Template ID	
00345	
Name	
2-D Position Modeling Template	
Description	
A palette of 2-20 images or animations is on the left side of the screen, the student moves any number of these images to the right modeling area to create positional relationships.	
Device Types	**Variable Attributes**
Image	(x,y)
Animation	(x,y)
Output description	
The (x,y) position of each of the images by concept name	
Output Data Format	

```
{
        "template" : {
                "name" : "2-D Position Modeling Template",
                "ID" : 00345
                },
        "devices" : {
                "<concept1>": {
                        "position" =(x,y)
                        },
                "<concept2>": {
                        "position" =(x,y)
                        },
                .....
                "<conceptN>": {
                        "position" =(x,y)
                        }
                }
}
```

FIG. 5

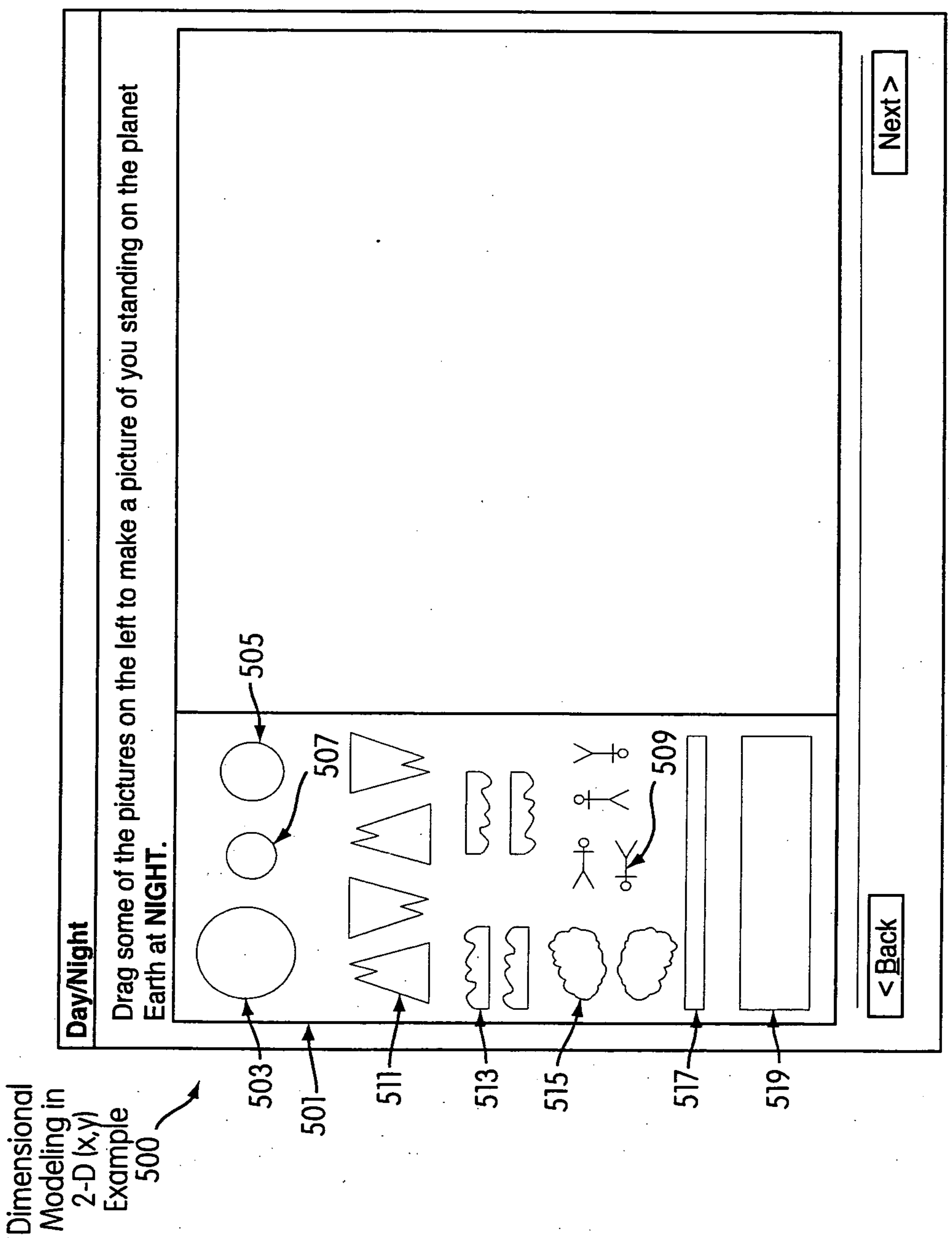

Dimensional Modeling in 2-D (x,y) Example 500
Day/Night
Drag some of the pictures on the left to make a picture of you standing on the planet Earth at **NIGHT.**
503
501
505
507
509
511
513
515
517
519
< Back
Next >

FIG. 6

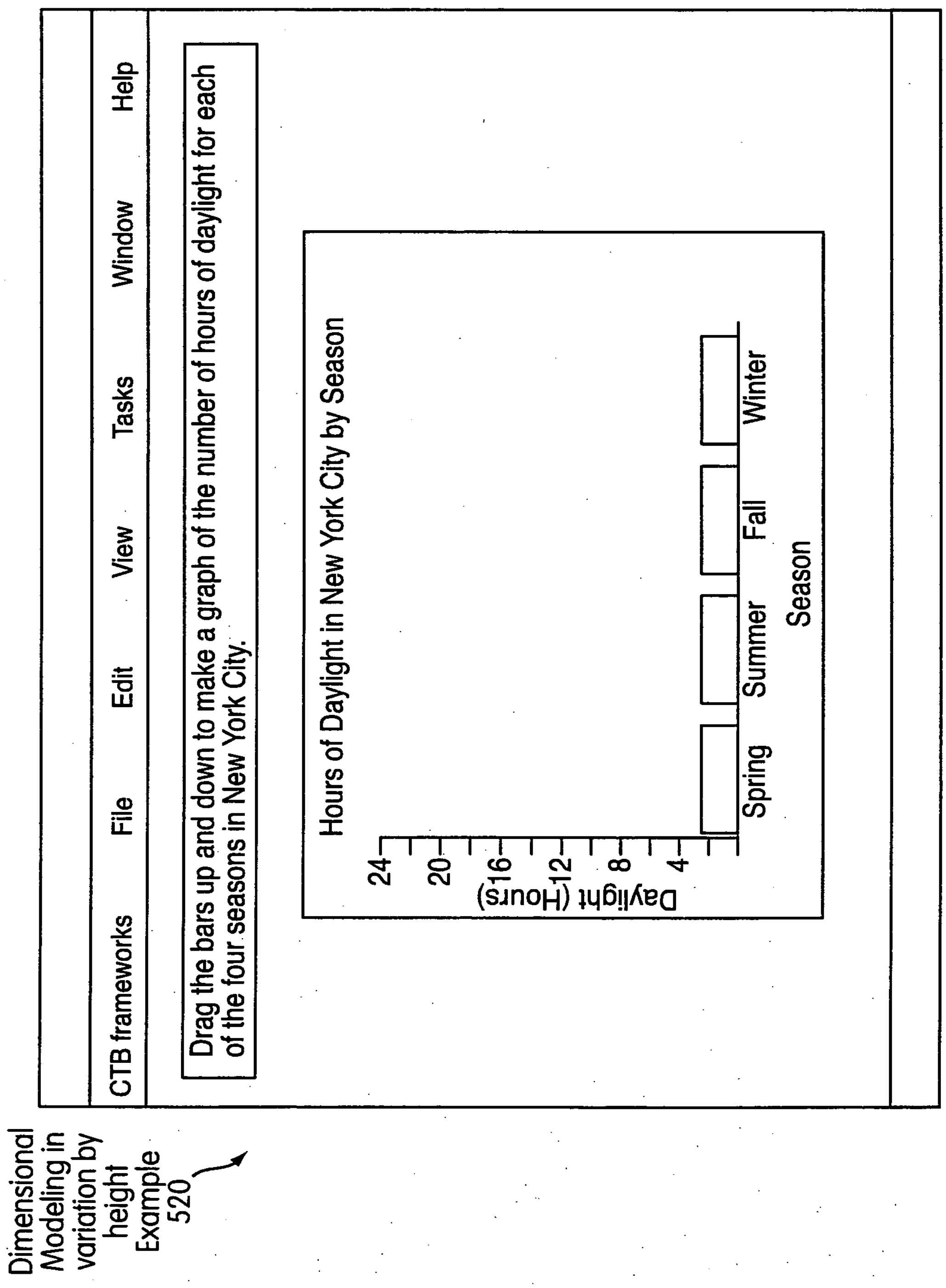

CTB frameworks
File
Edit
View
Tasks
Window
Help
Drag the bars up and down to make a graph of the number of hours of daylight for each of the four seasons in New York City.
Hours of Daylight in New York City by Season
Daylight (Hours)
24
20
16
12
8
4
Spring
Summer
Fall
Winter
Season
Dimensional Modeling in variation by height Example 520

FIG. 7a

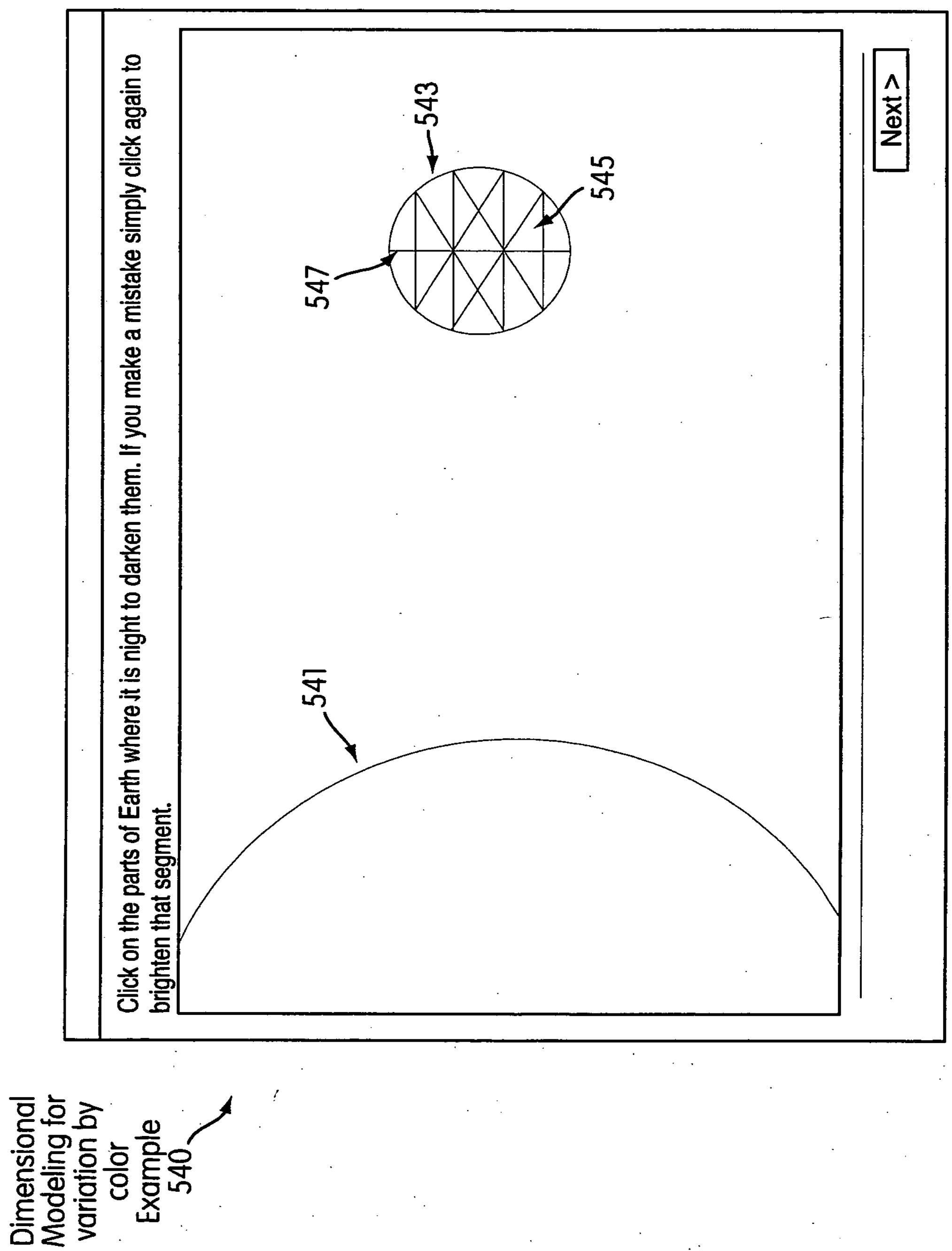

Click on the parts of Earth where it is night to darken them. If you make a mistake simply click again to brighten that segment.
541
543
545
547
Next >
Dimensional Modeling for variation by color Example
540

FIG. 7b

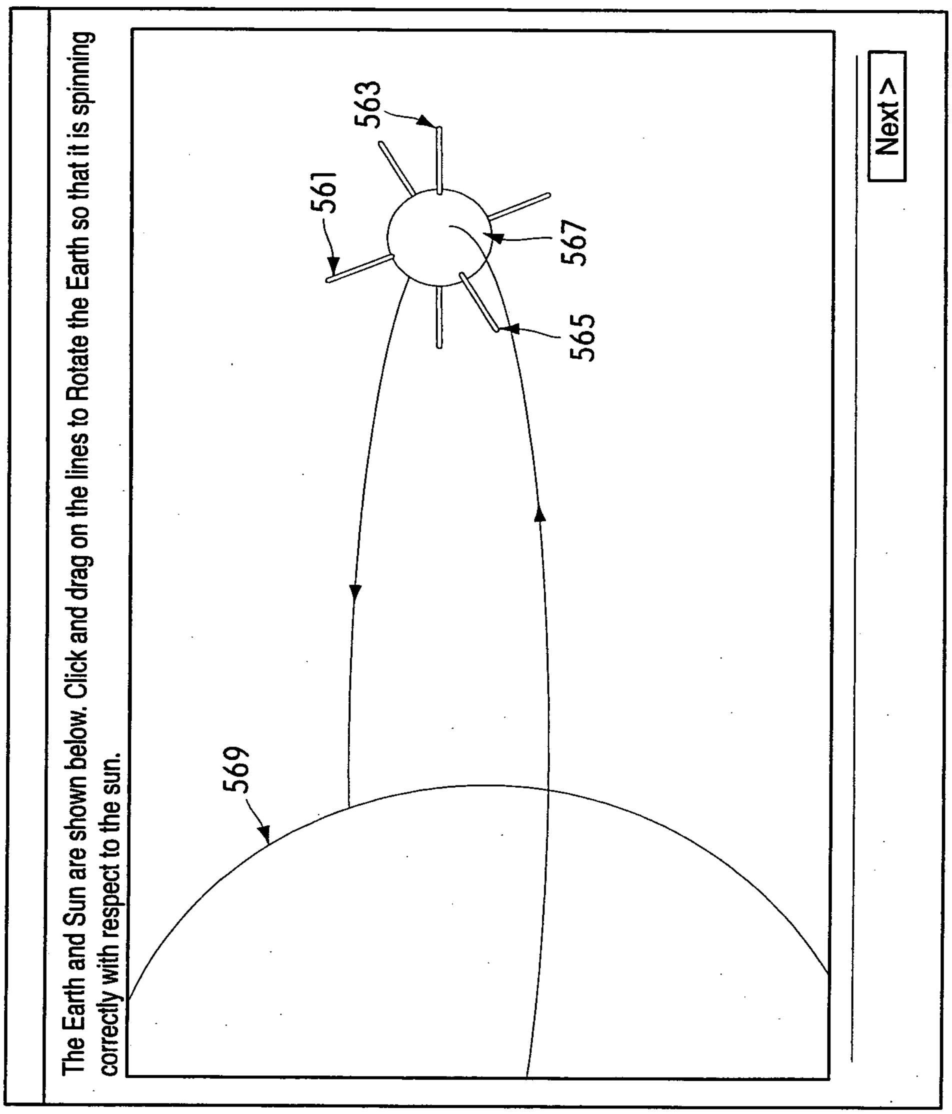


FIG. 7c

Dimensional Modeling for variation by orientation Example 560

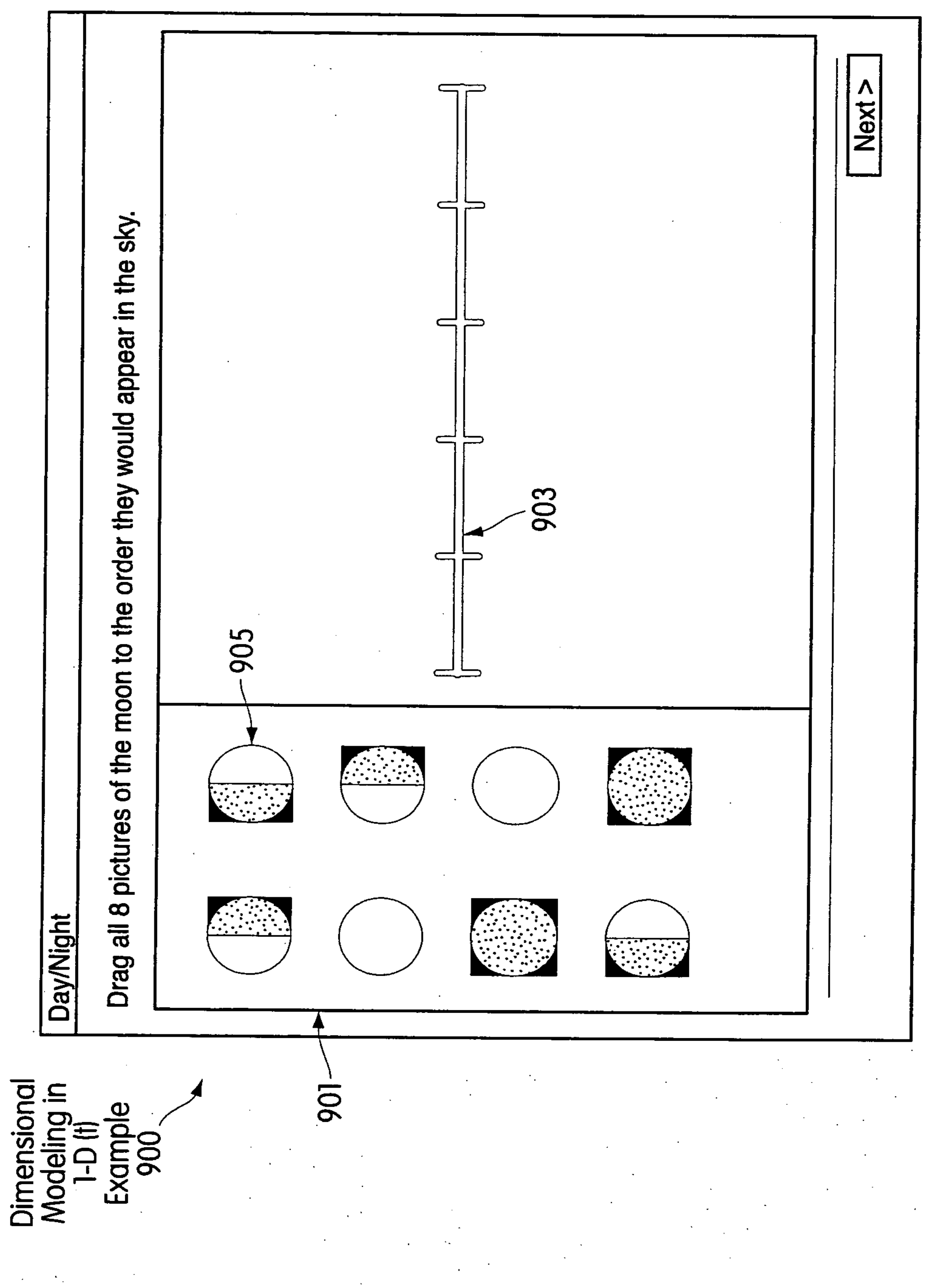

Day/Night
Drag all 8 pictures of the moon to the order they would appear in the sky.
Next >
905
903
901
Dimensional Modeling in 1-D (t) Example 900

FIG. 7d

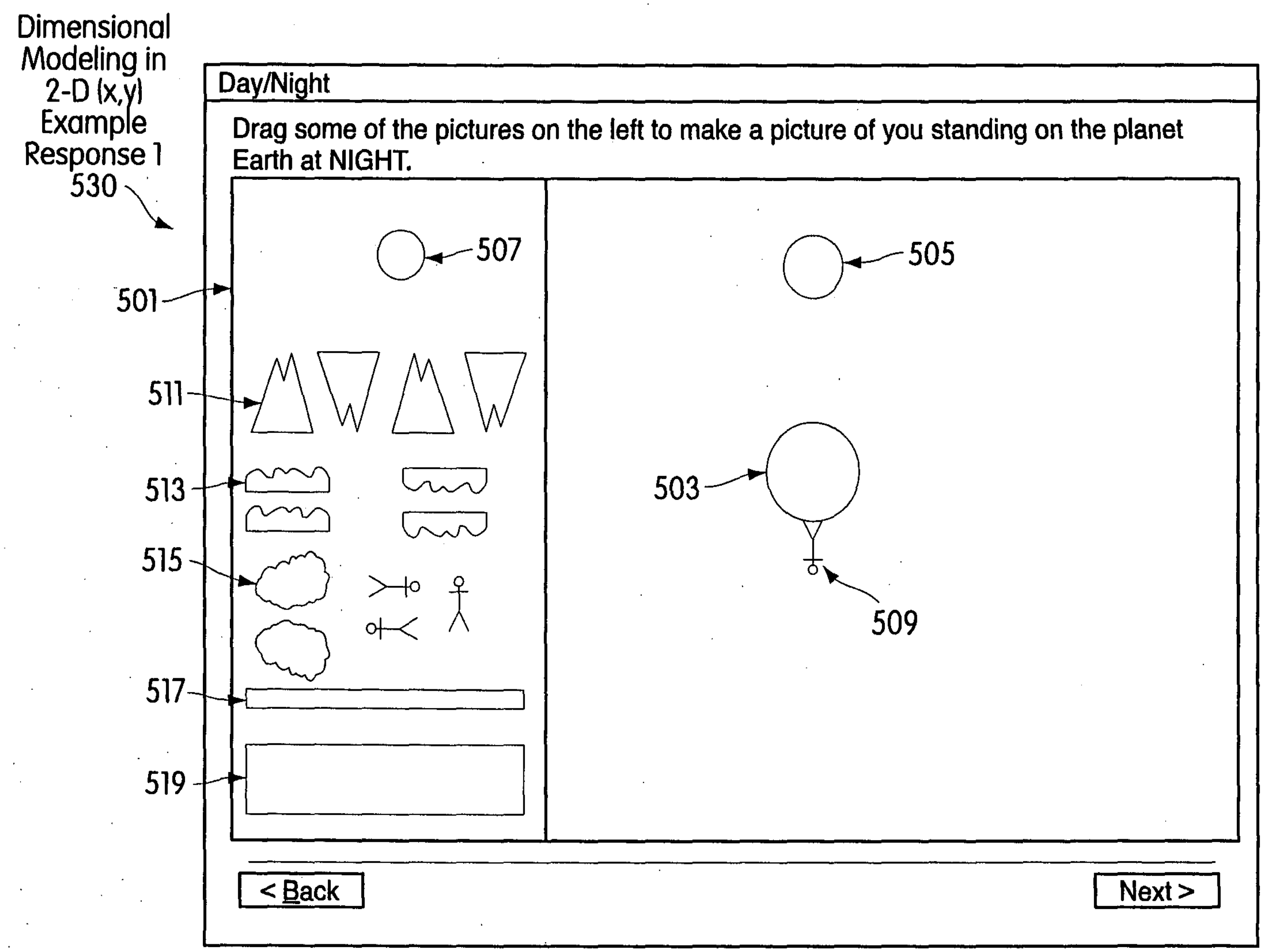

Dimensional
Modeling in
2-D (x,y)
Example
Response 1
530
Day/Night
Drag some of the pictures on the left to make a picture of you standing on the planet Earth at NIGHT.
501
507
505
511
513
503
515
509
517
519
< Back
Next >

FIG. 8

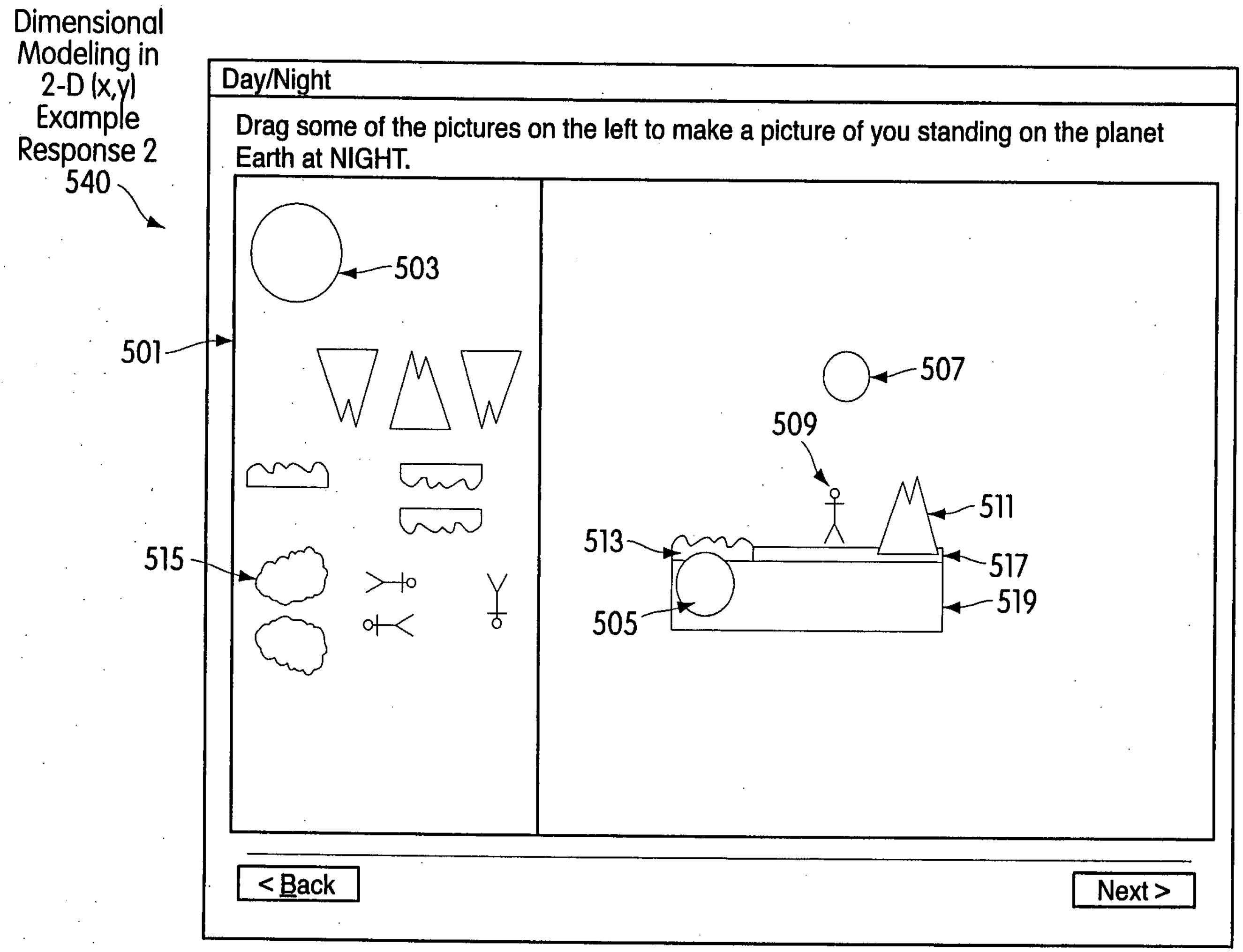

Dimensional Modeling in 2-D (x,y) Example Response 2
540
Day/Night
Drag some of the pictures on the left to make a picture of you standing on the planet Earth at NIGHT.
503
501
515
507
509
511
513
517
519
505
< Back
Next >

FIG. 9

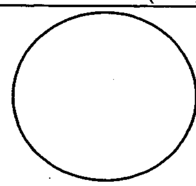
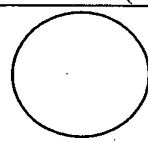
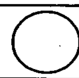
<table>
<tr><th rowspan="2">Concept</th><th colspan="2">Devices</th></tr>
<tr><th>3-D (x,y,t) computer based template</th><th>3-D (x,y,t) manual administration</th></tr>
<tr><td rowspan="2">Sun</td><td>Virtual Device (Image)</td><td>Physical Device (Ball)</td></tr>
<tr><td></td><td>Large size yellow rubber ball</td></tr>
<tr><td rowspan="2">Earth</td><td>Virtual Device (Image)</td><td>Physical Device (Ball)</td></tr>
<tr><td></td><td>Medium size blue plastic ball</td></tr>
<tr><td rowspan="2">Moon</td><td>Virtual Device (Image)</td><td>Physical Device (Ball)</td></tr>
<tr><td></td><td>Small size white ping-pong ball</td></tr>
<tr><td rowspan="2">Time</td><td>Virtual Device (Image)</td><td>Physical Device (Calendar)</td></tr>
<tr><td><table>
<tr><th>Su</th><th>M</th><th>Tu</th><th>W</th><th>Th</th><th>F</th><th>Sa</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>1</td><td>2</td></tr>
<tr><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td></tr>
<tr><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td></tr>
<tr><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr>
<tr><td>31</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>Braille/Regular calendar (depending on need)</td></tr>
<tr><td rowspan="2">Full Moon</td><td>Virtual Device (Image)</td><td>Physical Device (Voice)</td></tr>
<tr><td></td><td>"The moon when it appears to be bright and circular"</td></tr>
<tr><td rowspan="2">Half Waning Moon</td><td>Virtual Device (Image)</td><td>Physical Device (Voice)</td></tr>
<tr><td></td><td>"The moon when it appears the right side of a circle"</td></tr>
<tr><td rowspan="2">New Moon</td><td>Virtual Device (Image)</td><td>Physical Device (Voice)</td></tr>
<tr><td></td><td>"The moon when it appears to be completely dark"</td></tr>
<tr><td rowspan="2">Half Waxing Moon</td><td>Virtual Device (Image)</td><td>Physical Device (Voice)</td></tr>
<tr><td></td><td>"The moon when it appears to the left side of a circle"</td></tr>
</table>

FIG. 10

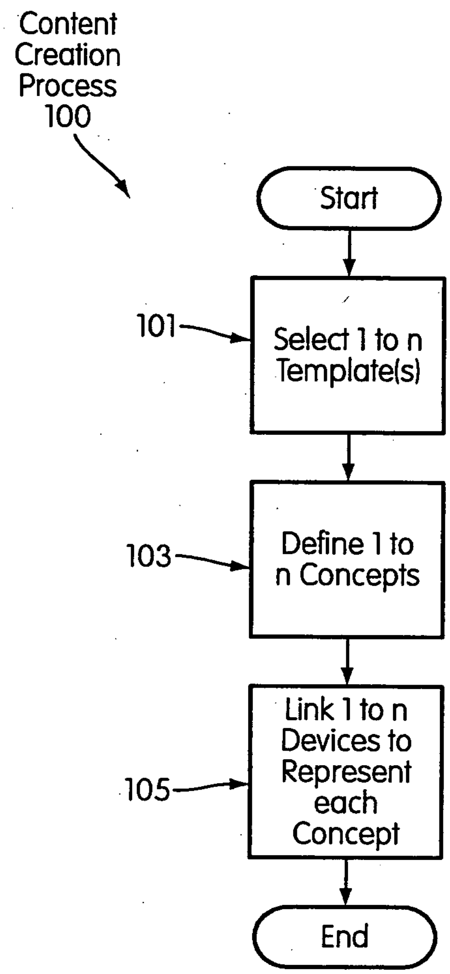

Content
Creation
Process
100
Start
101
Select 1 to n
Template(s)
103
Define 1 to
n Concepts
105
Link 1 to n
Devices to
Represent
each
Concept
End

FIG. 11

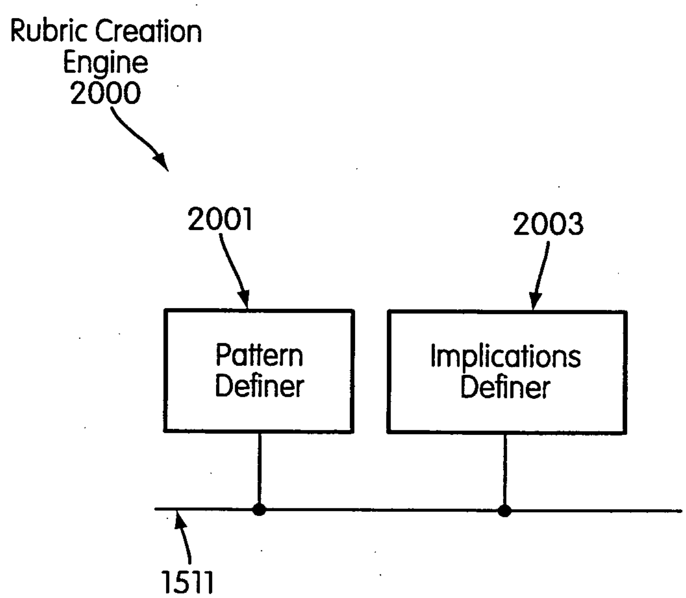

Rubric Creation
Engine
2000
2001
2003
Pattern
Definer
Implications
Definer
1511

FIG. 12

RELATIONSHIP	Formal Definition	
	2-Dimensional Model (x,y)	**3-Dimensional Model (x,y)**
<A> Above <B>	$A_{MinX} > B_{MaxX}$	$A_{MinZ} > B_{MinZ}$
<A> Below <B>	$A_{MinX} < B_{MaxX}$	$A_{MinZ} < B_{MinZ}$
<A> and <B> are on opposite sides of <C>	magnitude(**AC** + **BC**) < magnitude(**AC**) or magnitude(**AC** + **BC**) < magnitude(**BC**) (**AC** is defined as the vector between the center of device A and the center of device C, similarly **BC** is defined as the vector between the center of device B and the center of device C)	magnitude(**AC** + **BC**) < magnitude(**AC**) or magnitude(**AC** + **BC**) < magnitude(**BC**) (**AC** is defined as the vector between the center of device A and the center of device C, similarly **BC** is defined as the vector between the center of device B and the center of device C)
<A> and <B> are on the same sides of <C>	magnitude(**AC** + **BC**) > magnitude(**AC**) or magnitude(**AC** + **BC**) > magnitude(**BC**) (**AC** is defined as the vector between the center of device A and the center of device C, similarly **BC** is defined as the vector between the center of device B and the center of device C)	magnitude(**AC** + **BC**) > magnitude(**AC**) or magnitude(**AC** + **BC**) > magnitude(**BC**) (**AC** is defined as the vector between the center of device A and the center of device C, similarly **BC** is defined as the vector between the center of device B and the center of device C)
<A> Touching <B>	There is some point within the area covered by device A (A_x, A_y) such that (A_x+/-5 pixels,A_y+/- 5 pixels) is within the area covered by device B	There is some point within the volume occupied by device A (A_x, A_y, A_z) such that (A_x+/-5% of the maximum distance in x direction), A_y+/- 5% of the maximum distance in y direction, A_z+/- 5% of the maximum distance in z direction) is within the volume occupied by device B
<A> Inside <B>	$A_{MaxX} < B_{MaxX}$ and $A_{MinX} > B_{MinX}$ and $A_{MaxY} < B_{MaxY}$ and $A_{MinY} > B_{MinY}$	$A_{MaxX} < B_{MaxX}$ and $A_{MinX} > B_{MinX}$ and $A_{MaxY} < B_{MaxY}$ and $A_{MinY} > B_{MinY}$ and $A_{MaxZ} < B_{MaxZ}$ and $A_{MinZ} > B_{MinZ}$
<A> Bigger than <B>	The area covered by device A is greater than the area covered by Device B	The volume occupied by device A is greater than the volume occupied by device B
<A> Smaller than <B>	The area covered by device A is smaller than the area covered by Device B	The volume occupied by device A is smaller than the volume occupied by device B
<A> Taller than <B>	$A_{MaxY}-A_{MinY} > B_{MaxY}-B_{MinY}$	$A_{MaxZ}-A_{MinZ} > B_{MaxZ}-B_{MinZ}$
<A> Shorter than <B>	$A_{MaxY}-A_{MinY} < B_{MaxY}-B_{MinY}$	$A_{MaxZ}-A_{MinZ} < B_{MaxZ}-B_{MinZ}$
<A> Greater than <B>	$A_{value} > B_{value}$	$A_{value} > B_{value}$
<A> Less than <B>	$A_{value} < B_{value}$	$A_{value} < B_{value}$
<A> Darker than <B>	$A_{red}+A_{green}+A_{bue} < B_{red}+B_{green}+B_{bue}$ (where X_{color} indicates the RGB values for the color)	$A_{red}+A_{green}+A_{bue} < B_{red}+B_{green}+B_{bue}$ (where X_{color} indicates the RGB values for the color)
<A> Lighter than <B>	$A_{red}+A_{green}+A_{bue} > B_{red}+B_{green}+B_{bue}$ (where X_{color} indicates the RGB values for the color)	$A_{red}+A_{green}+A_{bue} > B_{red}+B_{green}+B_{bue}$ (where X_{color} indicates the RGB values for the color)
<A> Same color as <B>	$A_{red} = B_{red}$ and $A_{green} = B_{green}$ and $A_{blue} = B_{blue}$	$A_{red} = B_{red}$ and $A_{green} = B_{green}$ Aand $A_{blue} = B_{blue}$
<A> Same size as <B>	$A_{MaxY}-A_{MinY} = B_{MaxY}-B_{MinY}$ +/- 5% of $B_{MaxY}-B_{MinY}$) and $A_{MaxX}-A_{MinX} = B_{MaxX}-B_{MinX}$ +/- 5% of $B_{MaxX}-B_{MinX}$)	$A_{MaxY}-A_{MinY} = B_{MaxY}-B_{MinY}$ +/- 5% of $B_{MaxY}-B_{MinY}$) and $A_{MaxX}-A_{MinX} = B_{MaxX}-B_{MinX}$ +/- 5% of $B_{MaxX}-B_{MinX}$) and $A_{MaxZ}-A_{MinZ} = B_{MaxZ}-B_{MinZ}$ +/- 5% of $B_{MaxZ}-B_{MinZ}$)
<A> Same length as <B>	The longest dimension of A is greater than the longest dimension of B	The longest dimension of A is greater than the longest dimension of B
<A> Same intensity as <B>	For the HSB values of the devices, the Brightness of A is greater than the brightness of B	For the HSB values of the devices, the Brightness of A is greater than the brightness of B

FIG. 13

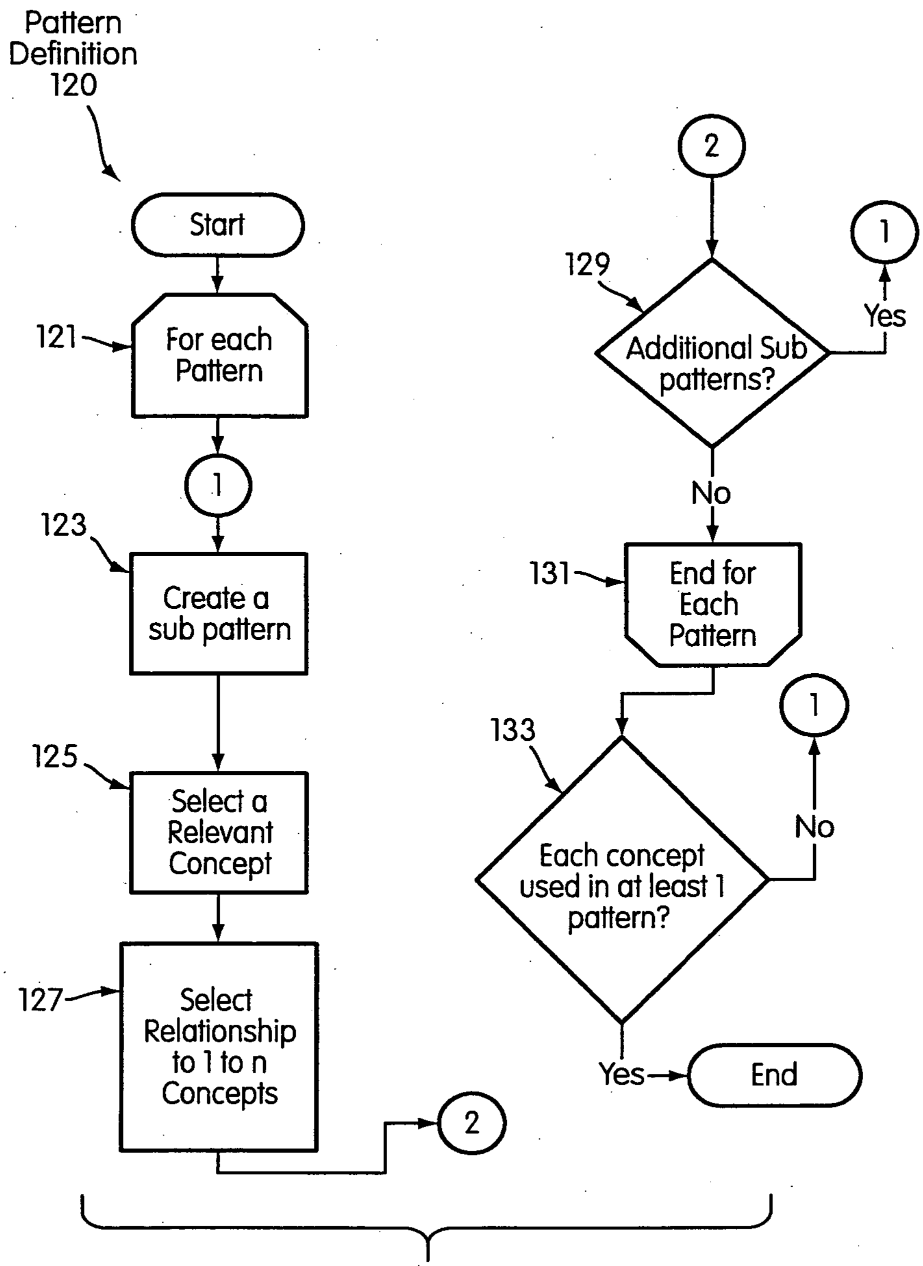

Pattern Definition 120
Start
121
For each Pattern
1
123
Create a sub pattern
125
Select a Relevant Concept
127
Select Relationship to 1 to n Concepts
2
2
129
Additional Sub patterns?
Yes
1
No
131
End for Each Pattern
133
Each concept used in at least 1 pattern?
No
1
Yes
End

FIG. 14

Pattern	**Sub Patterns**		**Implication Type**	**Implication Value**
"Night"	"Person" and "Sun" on the opposite sides of "Earth"		"score"	3
			"reward"	(image="goldstar.jpg", sound="hurray.au")
			"correct"	1
			"knowledge"	{("sun is on the opposite side of earth at night", 0.95), ("sunlight makes daylight", 0.99)}
			"navigation"	ItemID=88921
"Moon makes Night"	"Person" and "Moon" on the same side of "Earth"		"score"	0
	"Sun" not used		"reward"	(sound="goodtry.au")
			"correct"	0
			"knowledge"	{("sun is on the opposite side of earth at night", -0.95)}
			"navigation"	ItemID=12346
"Sun goes into Flat Earth"	"Flat Earth" used		"score"	1
	"Sun" inside "Flat Earth"		"reward"	(sound="oops.au")
			"correct"	0
			"knowledge"	{("sun is on the other side of earth at night", -.99),("the earth is shaped like a ball", -0.50
			"navigation"	ItemID=07685

FIG. 15

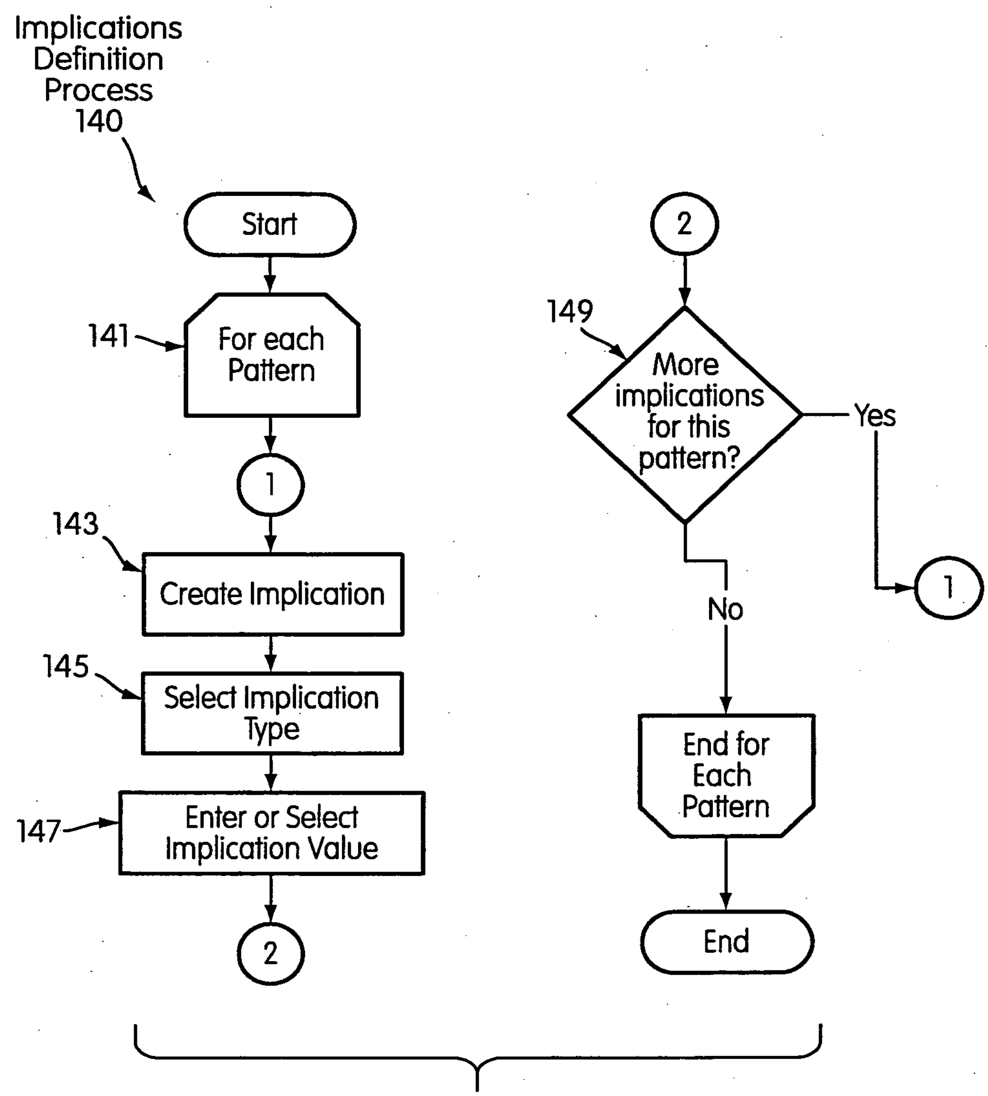

Implications Definition Process 140
Start
141
For each Pattern
1
143
Create Implication
145
Select Implication Type
147
Enter or Select Implication Value
2
2
149
More implications for this pattern?
Yes
1
No
End for Each Pattern
End

FIG. 16

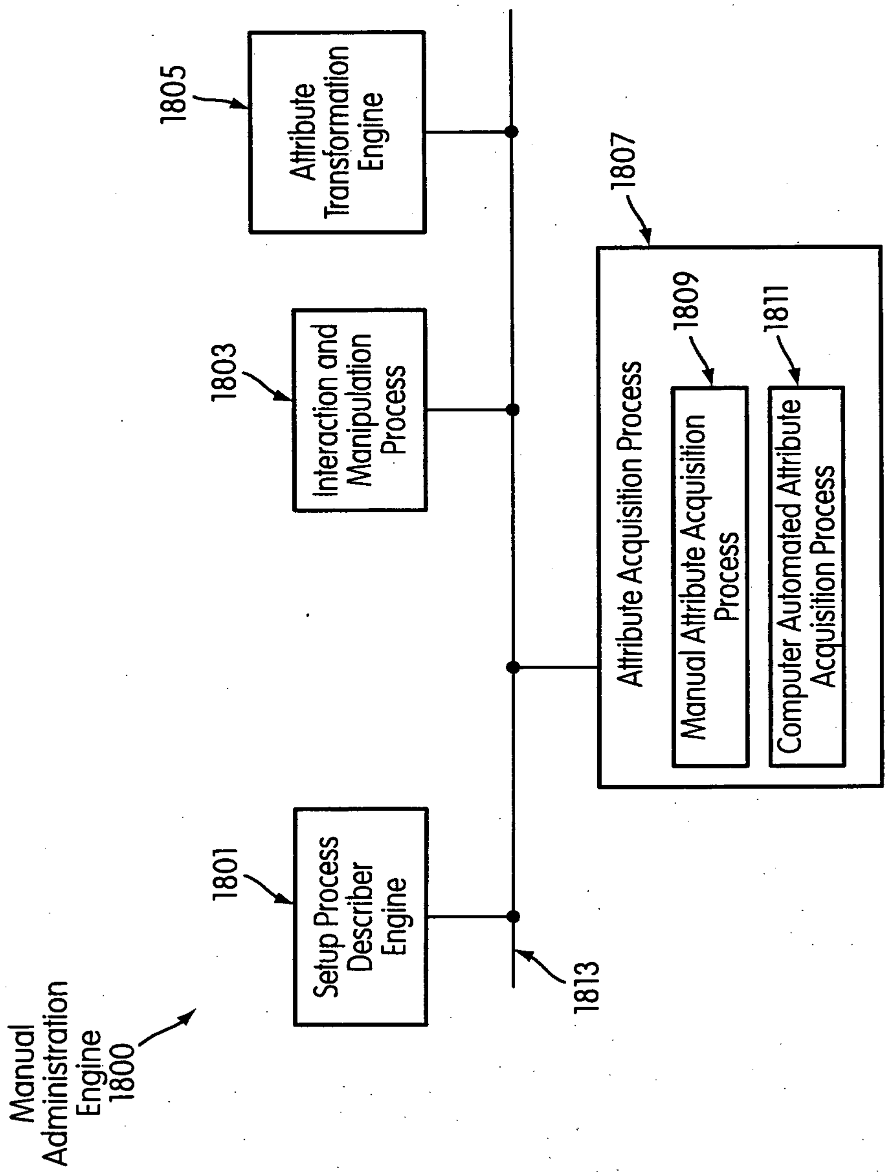

Manual Administration Engine 1800
1801
Setup Process Describer Engine
1803
Interaction and Manipulation Process
1805
Attribute Transformation Engine
1807
Attribute Acquisition Process
1809
Manual Attribute Acquisition Process
1811
Computer Automated Attribute Acquisition Process
1813

FIG. 17

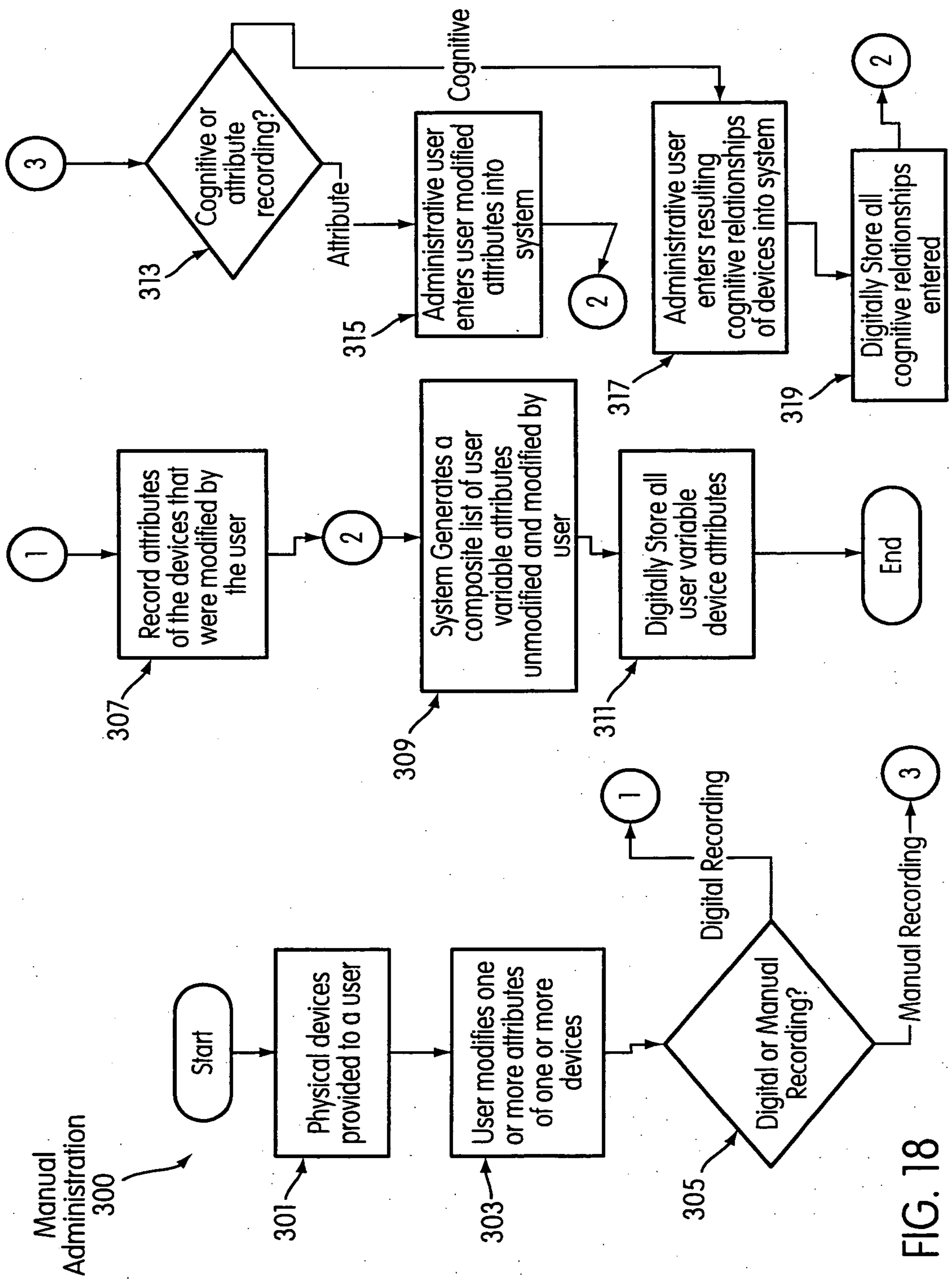

Manual Administration 300
Start
301
Physical devices provided to a user
303
User modifies one or more attributes of one or more devices
305
Digital or Manual Recording?
Digital Recording
Manual Recording
1
3
307
Record attributes of the devices that were modified by the user
2
309
System Generates a composite list of user variable attributes unmodified and modified by user
311
Digitally Store all user variable device attributes
End
313
Cognitive or attribute recording?
Attribute
Cognitive
315
Administrative user enters user modified attributes into system
317
Administrative user enters resulting cognitive relationships of devices into system
319
Digitally Store all cognitive relationships entered

FIG. 18

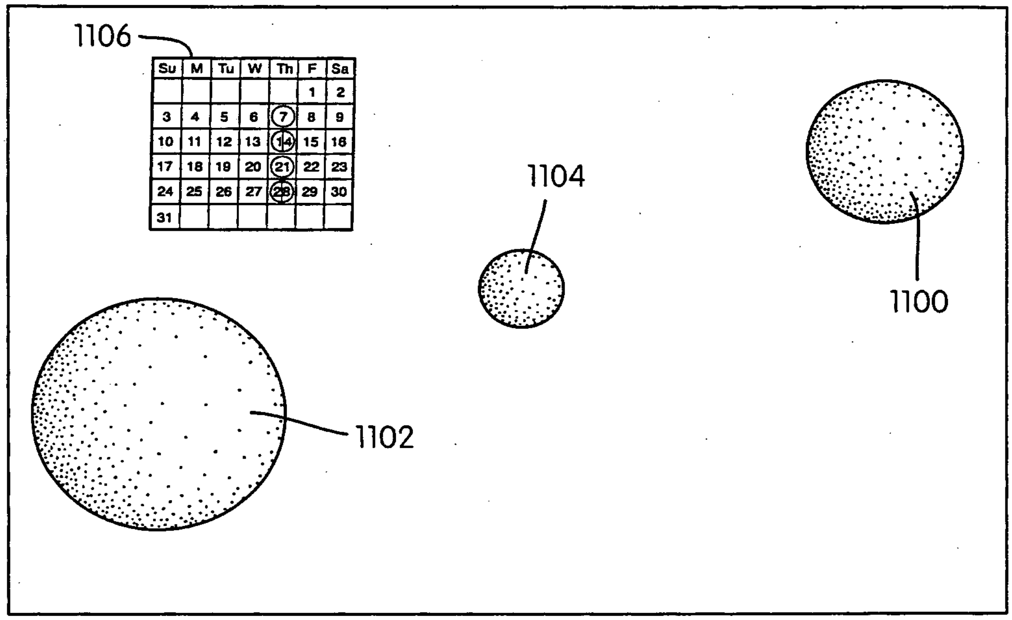


FIG. 19a

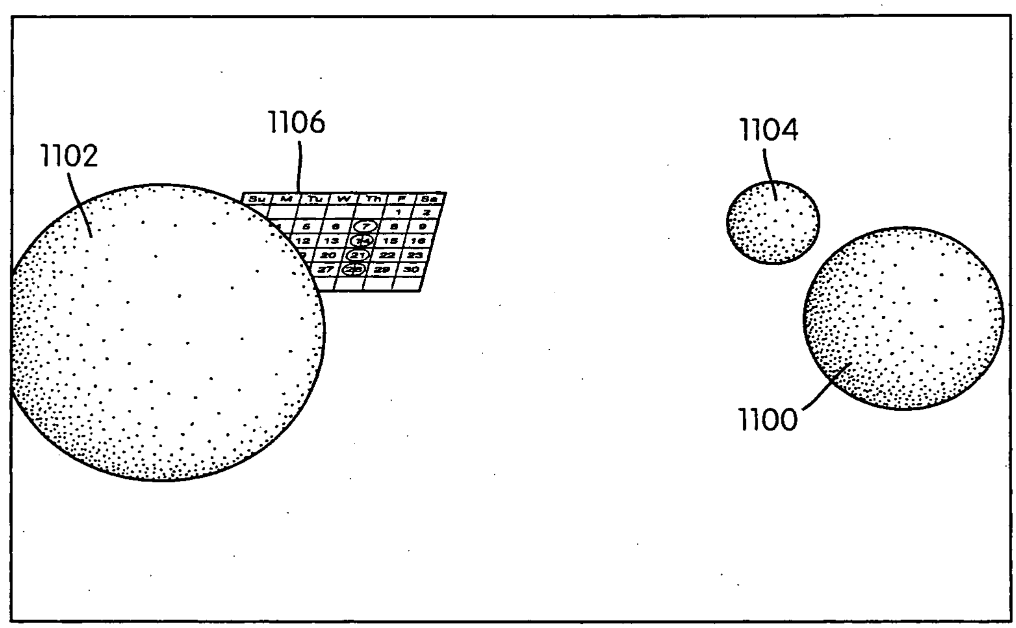


FIG. 19b

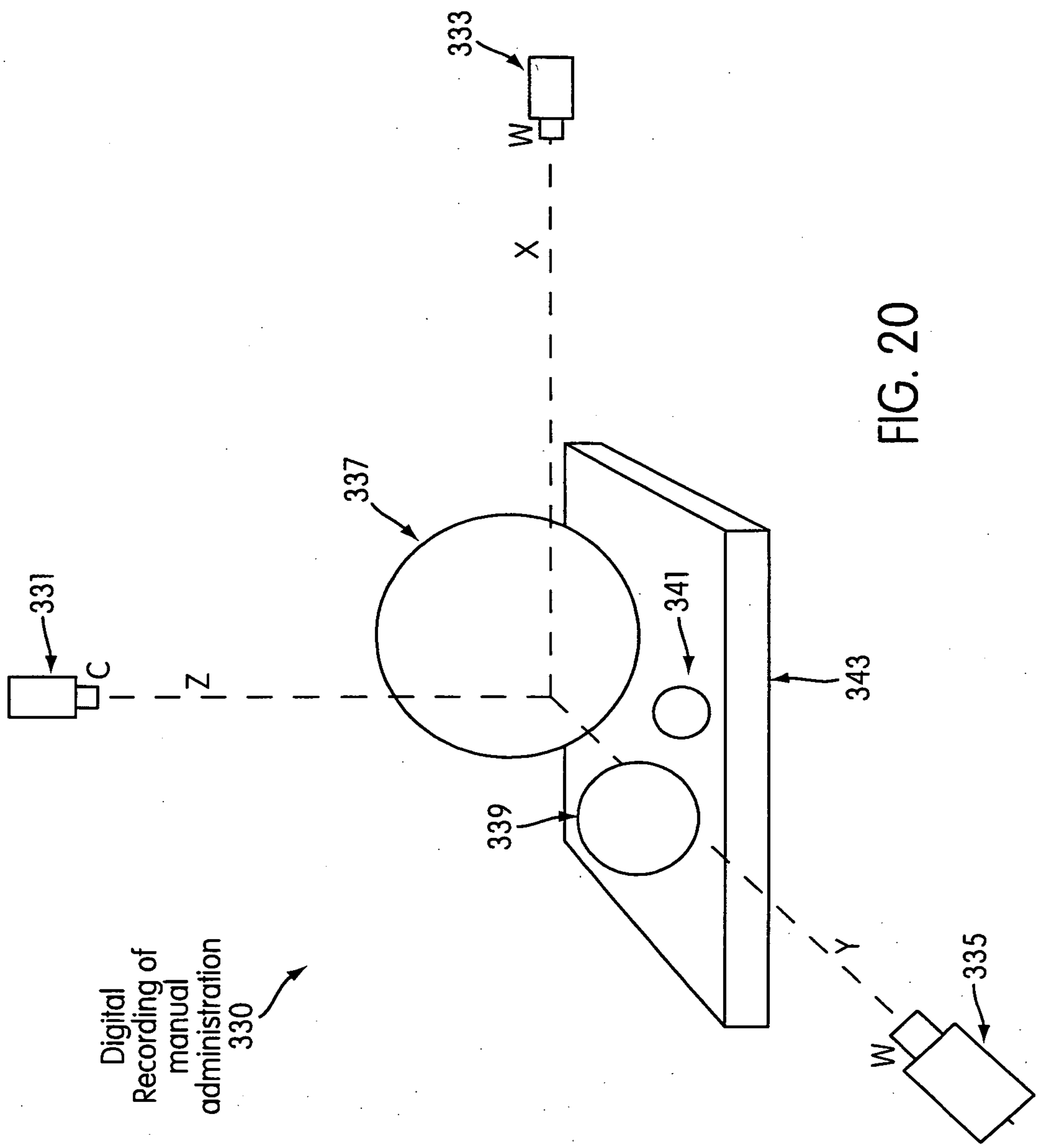

333
W
X
337
331
C
Z
341
343
339
Y
335
W
Digital Recording of manual administration 330

FIG. 20

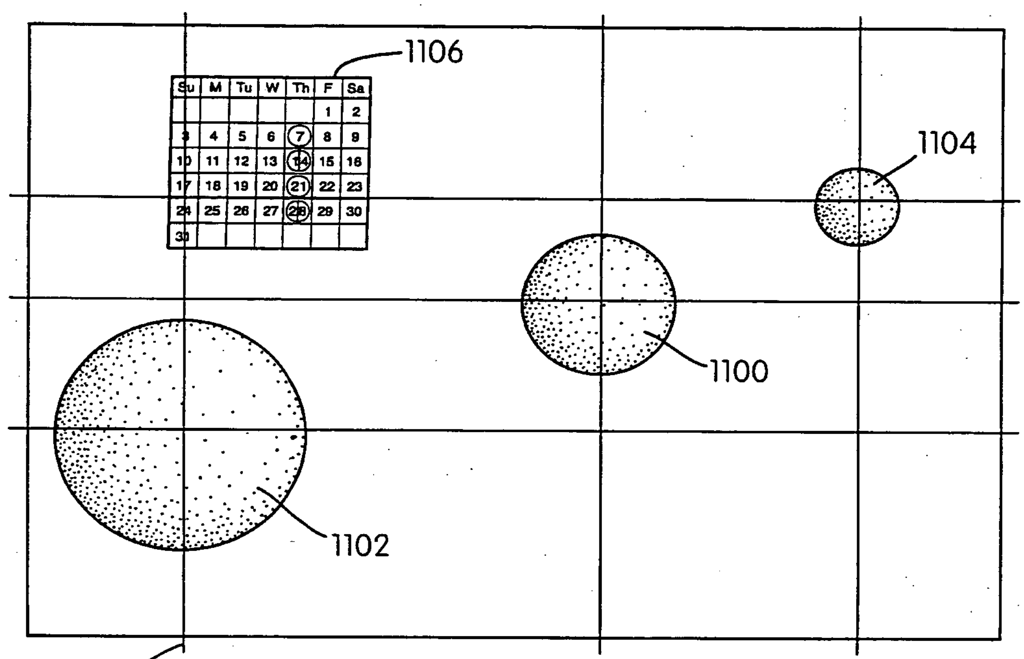


FIG. 21a

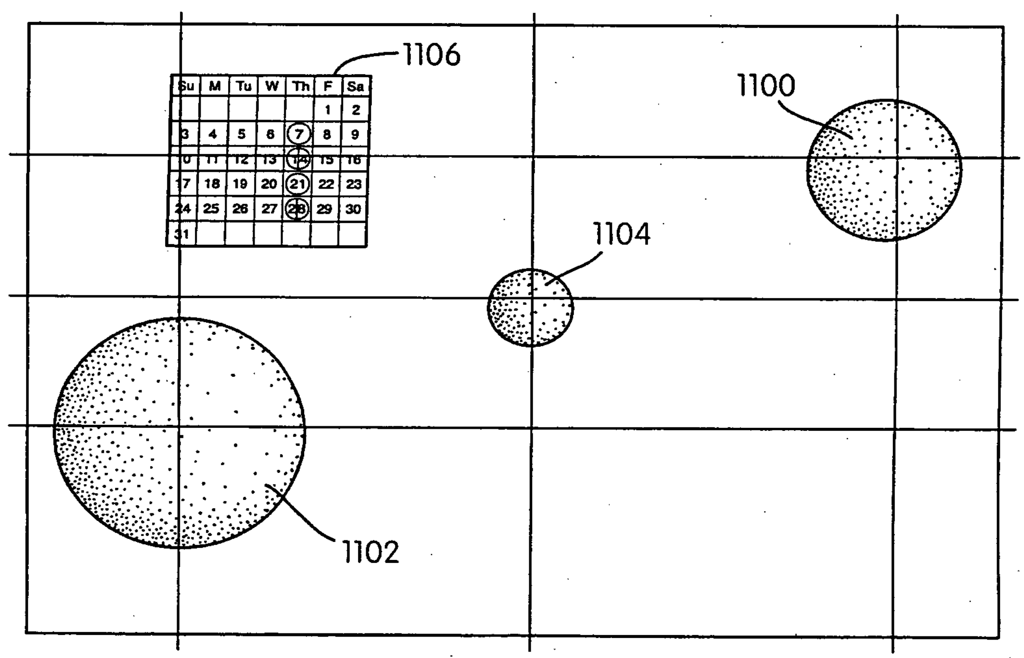


FIG. 21b

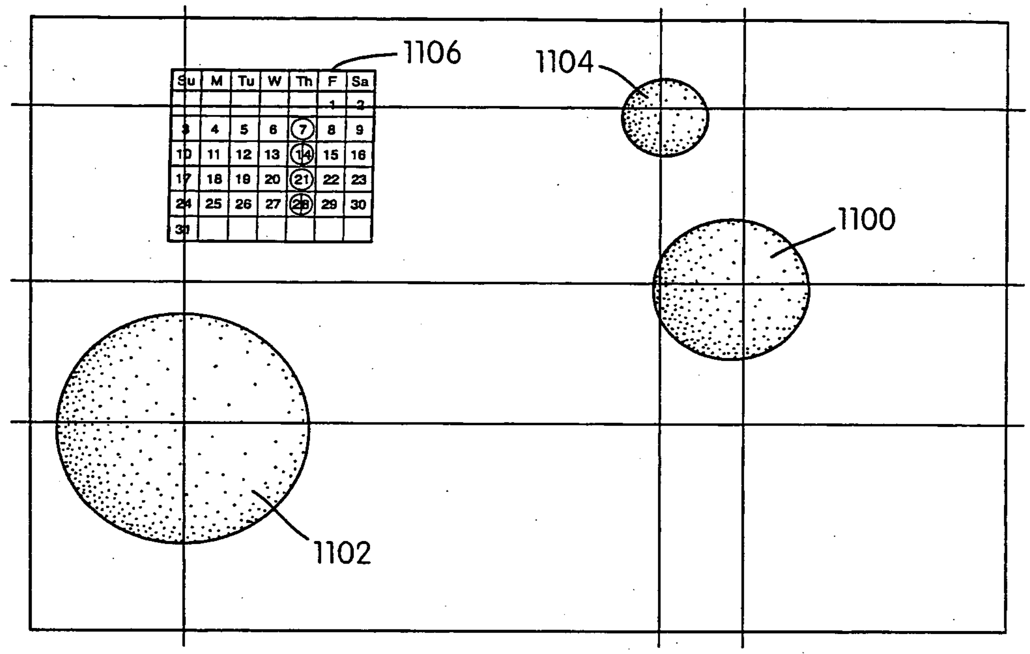


FIG. 21c

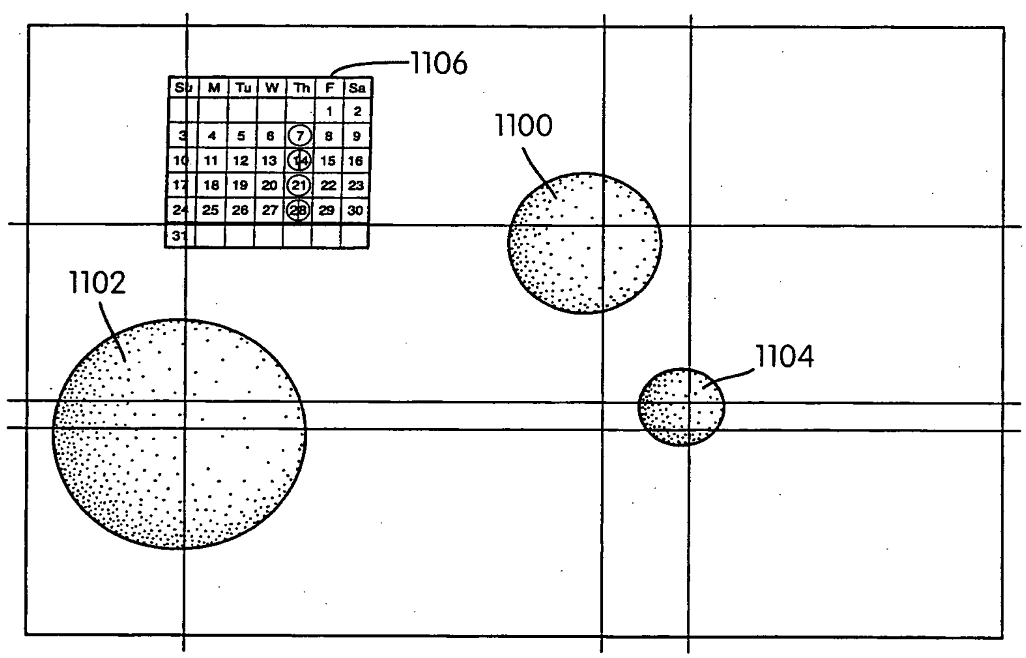


FIG. 21d

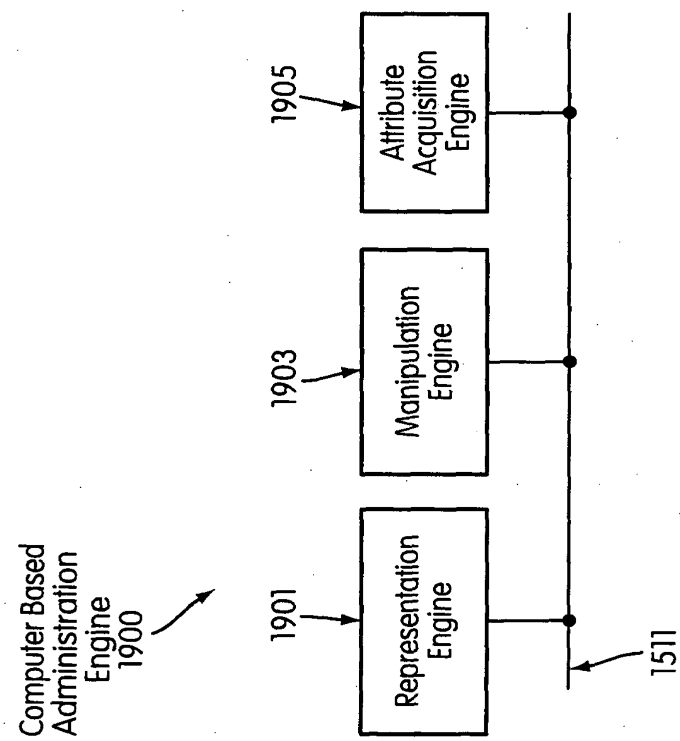

Computer Based Administration Engine 1900
1901
Representation Engine
1903
Manipulation Engine
1905
Attribute Acquisition Engine
1511

FIG. 22

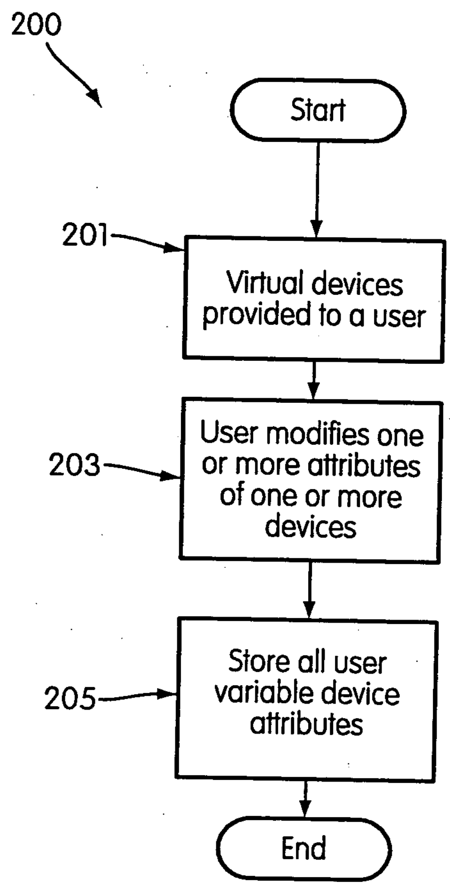

200
Start
201
Virtual devices provided to a user
203
User modifies one or more attributes of one or more devices
205
Store all user variable device attributes
End

FIG. 23

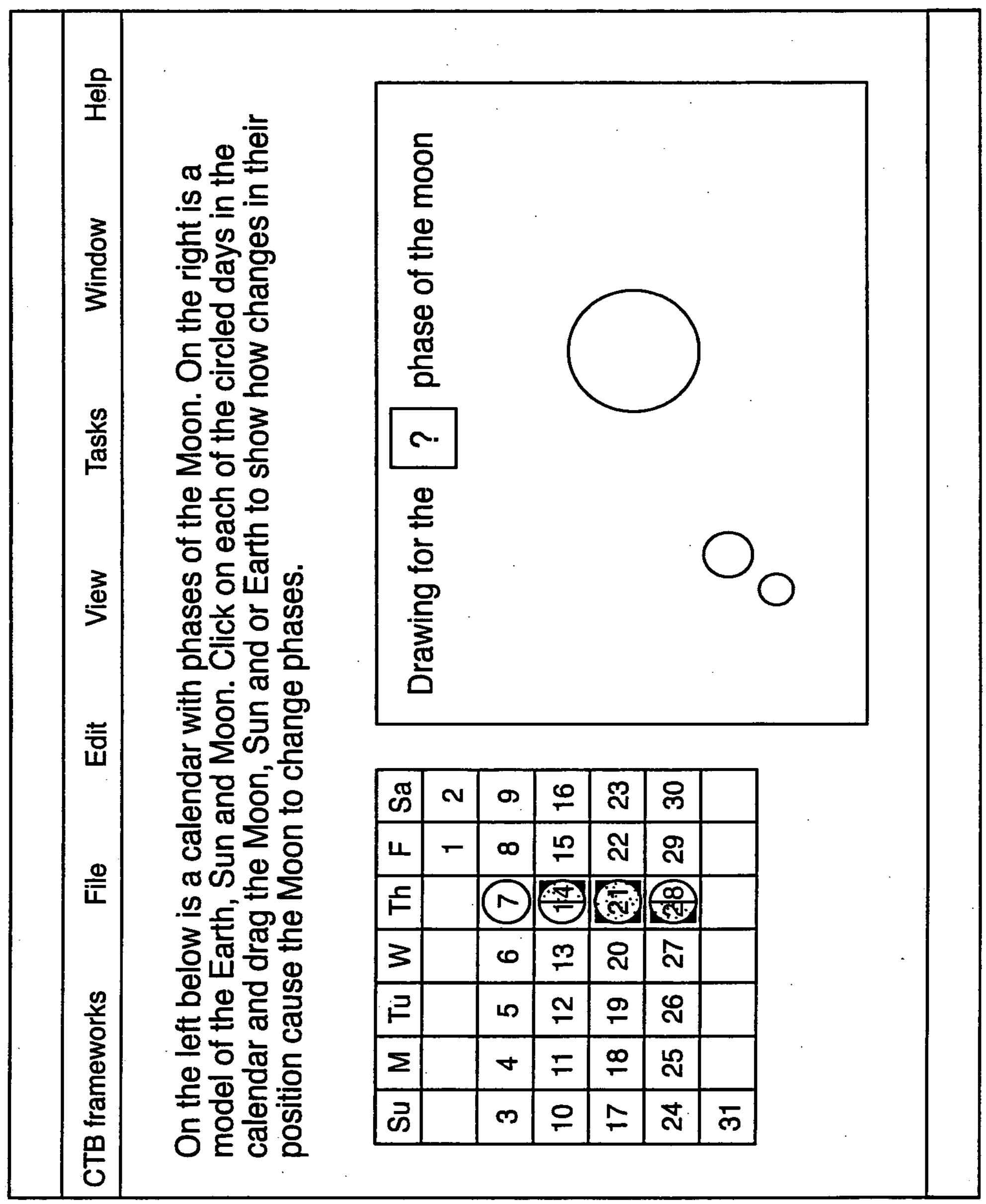

CTB frameworks
File
Edit
View
Tasks
Window
Help
On the left below is a calendar with phases of the Moon. On the right is a model of the Earth, Sun and Moon. Click on each of the circled days in the calendar and drag the Moon, Sun and or Earth to show how changes in their position cause the Moon to change phases.
Su M Tu W Th F Sa
1 2
3 4 5 6 7 8 9
10 11 12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
31
Drawing for the ? phase of the moon

FIG. 24

```
{
        "template" = {
                "name" : "2-D Position Modeling Template",
                 "ID" : 00345
                },
        "item" = {
                "name" : "Phase of the Moon Calendar Model",
                "ID" : 007755
                },
        "devices" = {
                "Sun": {
                        [(30,100,7),(30,100,14),(30,100,21),(30,100,28)]
                        },
                "Earth" : {
                        [(71,203,7),(71,203,14),(71,203,21),(71,210,28)]
                        },
                "Moon" : {
                        [(93,132,7),(170,58,14),(120,274,21),(93,254,28)]
                        }
                }
}
```


FIG. 25

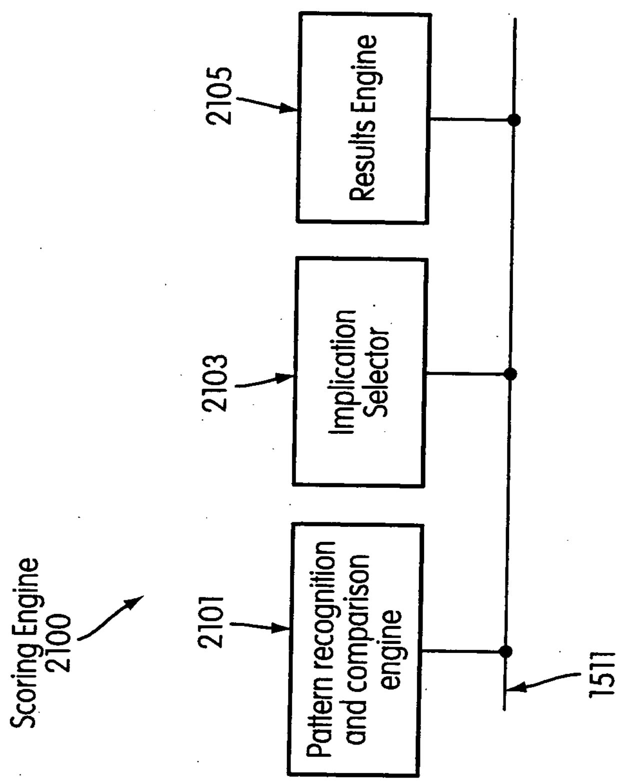

Scoring Engine
2100
2101
Pattern recognition and comparison engine
2103
Implication Selector
2105
Results Engine
1511

FIG. 26

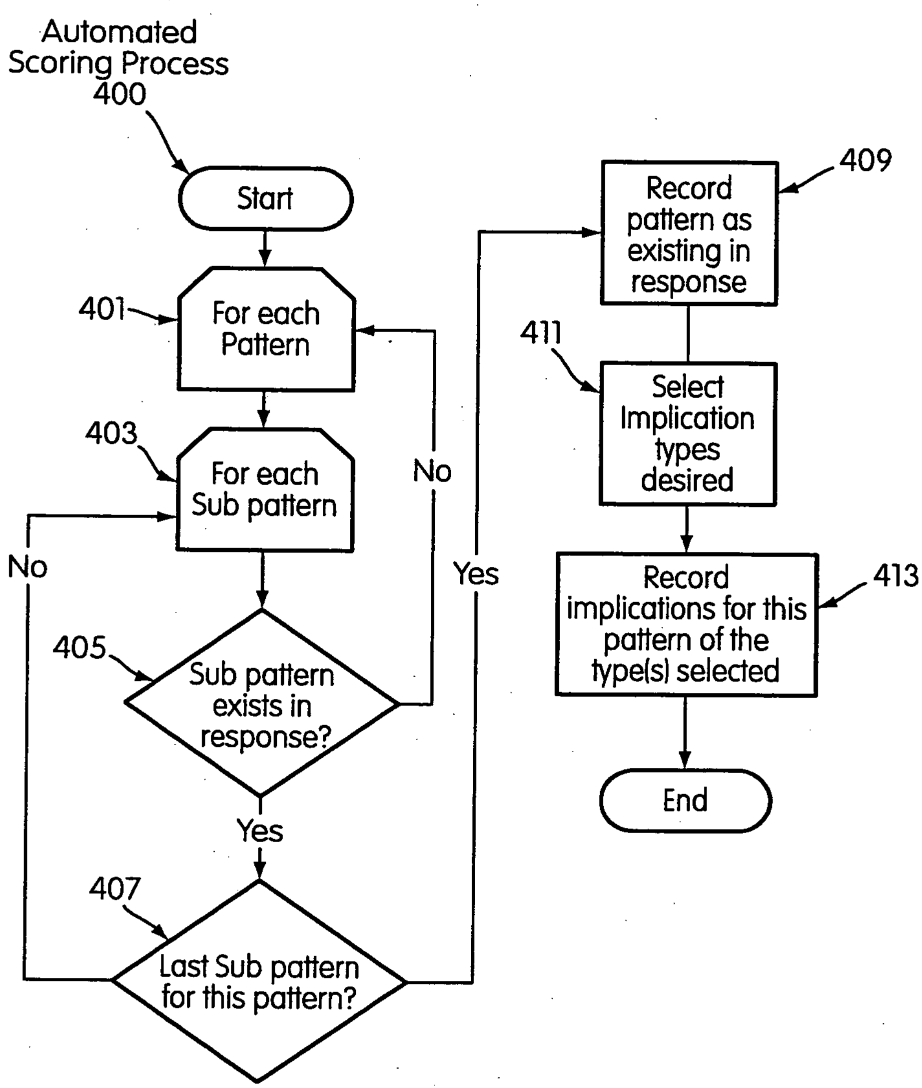

Automated Scoring Process 400
Start
401
For each Pattern
403
For each Sub pattern
No
405
Sub pattern exists in response?
No
Yes
407
Last Sub pattern for this pattern?
Yes
Record pattern as existing in response
409
411
Select Implication types desired
Record implications for this pattern of the type(s) selected
413
End

FIG. 27